Thermal transparent inverse design based on different methods

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I. INTRODUCTION

Recent years have witnessed significant advancements in utilizing machine learning techniques for designing thermal metamaterial-based structures and devices to achieve favorable thermal transport behaviors. In this work, we employ a thermal metamaterial-based periodic interparticle system as the foundational structure[1] for manipulating thermal transport properties and achieving thermal transparency. We explore various machine learning approaches for the thermally transparent inverse design, including diffusion models, graph neural networks, and conditional variational autoencoders and so on[2-4].

II. Periodic Interparticle System (PIS)

we propose a mechanism that utilizes a Periodic Interparticle System (PIS) as a fundamental approach to achieve thermal transparency. Type A particles possess a circular shape and anisotropic thermal conductivities, while Type B particles have an elliptical shape and isotropic thermal conductivities. These two particle types are systematically arranged on a periodic lattice in relation to the background.

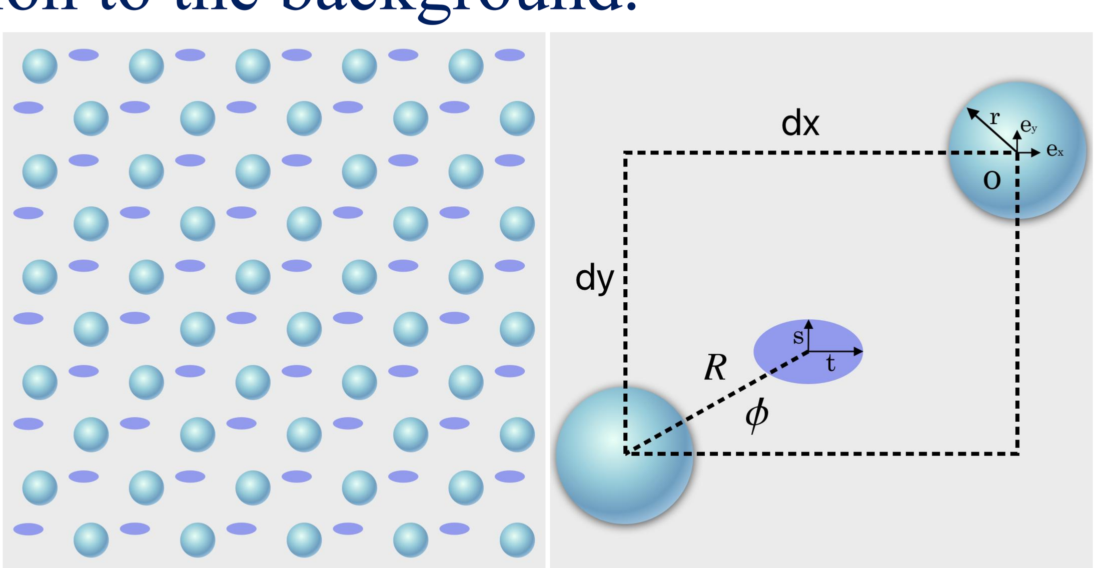

Fig. 1 Periodic composite material and basic structures[1]

III. METHODS

We control thermal energy from two perspectives. One is to design new structures, and the other is to use different methods to design, such as machine learning.

Method 1:

Structure property: thermal metamaterials + New method: Machine Learning → Control the heat energy

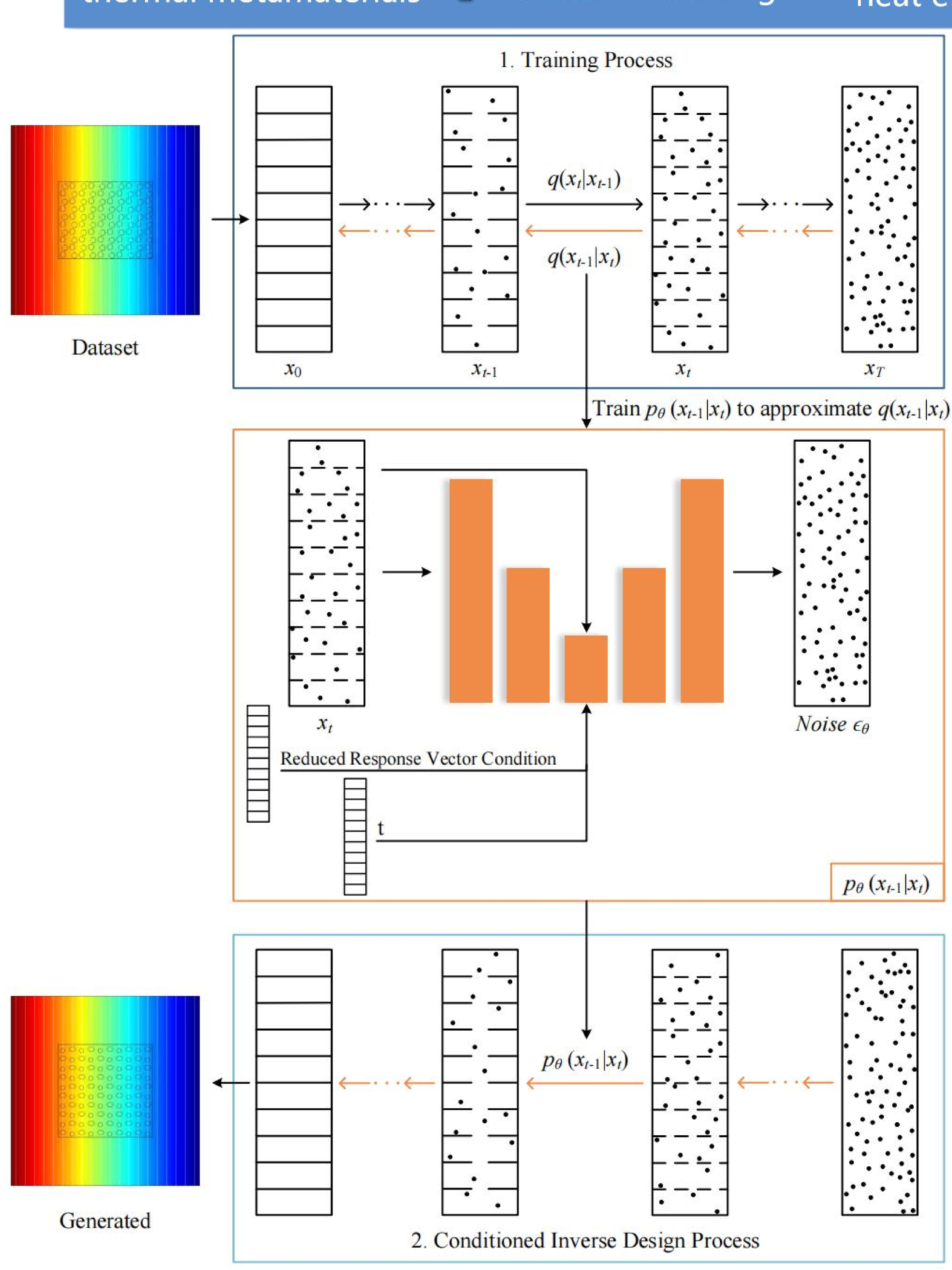

Fig. 2 Denoising diffusion probability model[2]

Method 2:

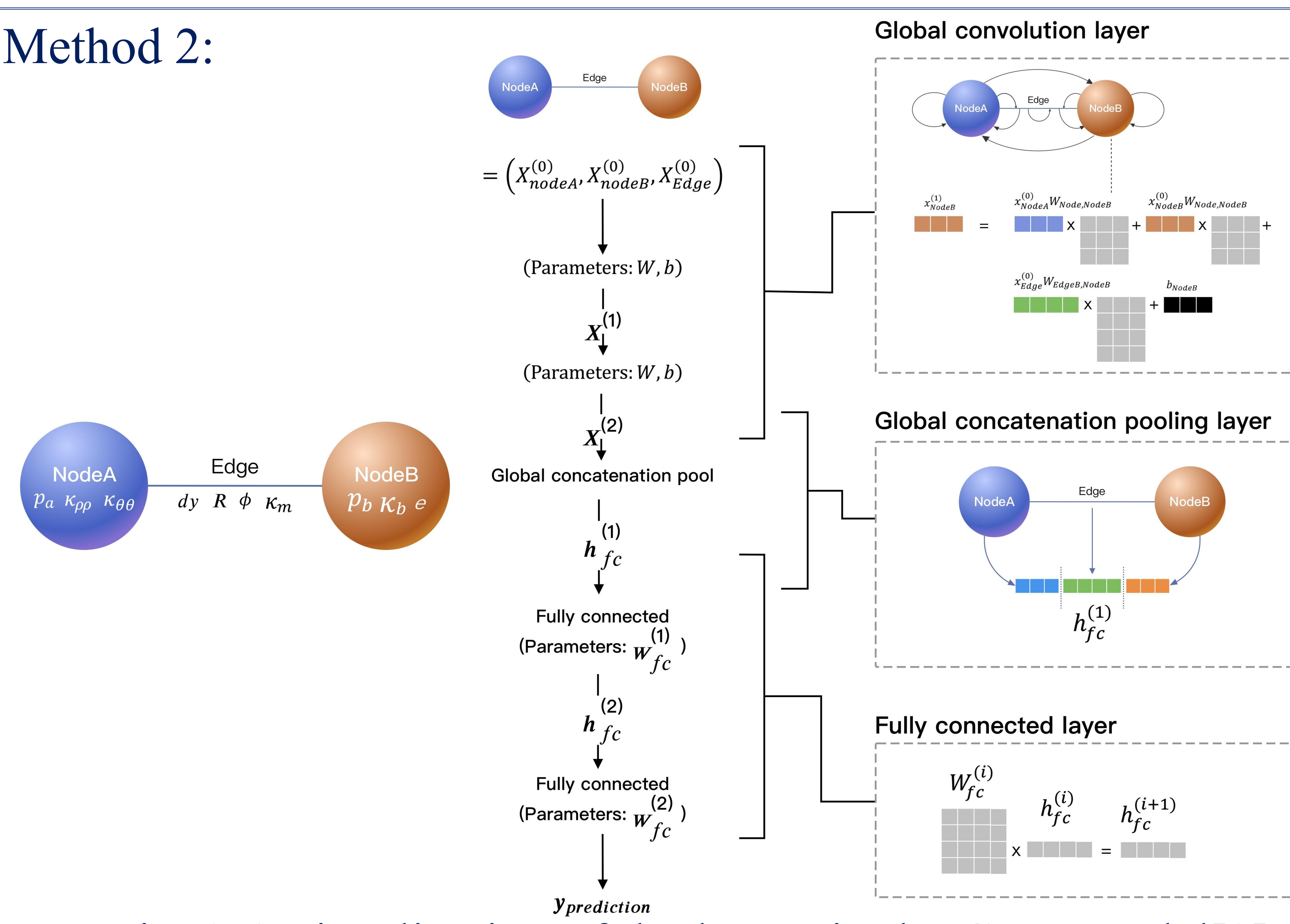

Fig. 3 A visualization of the layers in the GNN model[3]

IV. RESULTS

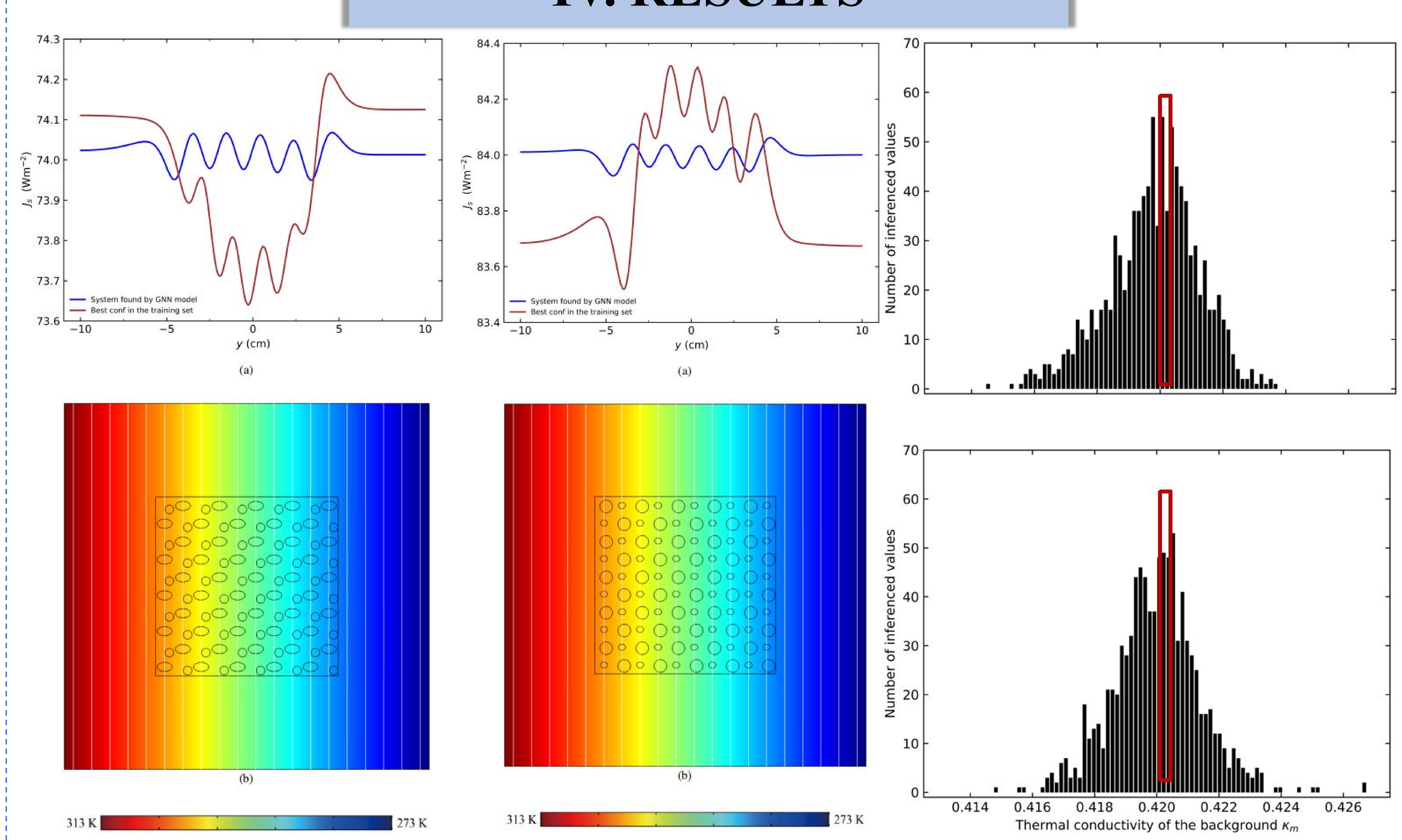

Fig. 4 Finite-element simulations[2]

V. CONCLUSION

In our previous work, we demonstrated that both the diffusion model and the graph neural network are highly effective for thermally transparent inverse design. These models have proven to be versatile and powerful tools for addressing inverse design challenges.

References:

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